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Tanaka

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(54) **TURBINE ROTOR, TURBINE, AND METHOD FOR REMOVING SEAL PLATE**

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(Continued)

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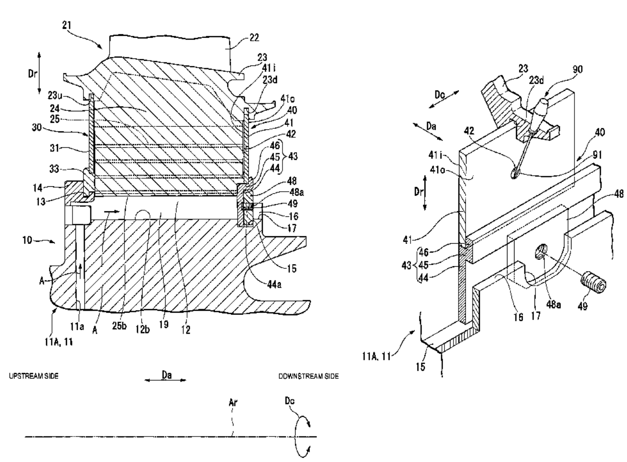
(57) **ABSTRACT**

A turbine rotor includes: a rotor shaft part; a plurality of blades secured to an outer periphery of the rotor shaft part; and a seal plate configured to be fitted into a groove and configured to seal off a flow of gas in an axial direction, the groove being defined in a platform of one of the blades so as to be recessed toward an outer side in a radial direction and to extend in a peripheral direction. A blind tool hole into which a removing tool can be inserted is defined in an outside surface of the seal plate opposite an inside surface that faces a blade root of the one of the blades.

8 Claims, 13 Drawing Sheets



(52) **U.S. Cl.**
CPC ***F01D 11/006*** (2013.01); *F05D 2230/68* (2013.01); *F05D 2230/70* (2013.01); *F05D 2260/30* (2013.01); *Y10T 29/49323* (2015.01)

(58) **Field of Classification Search**
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See application file for complete search history.

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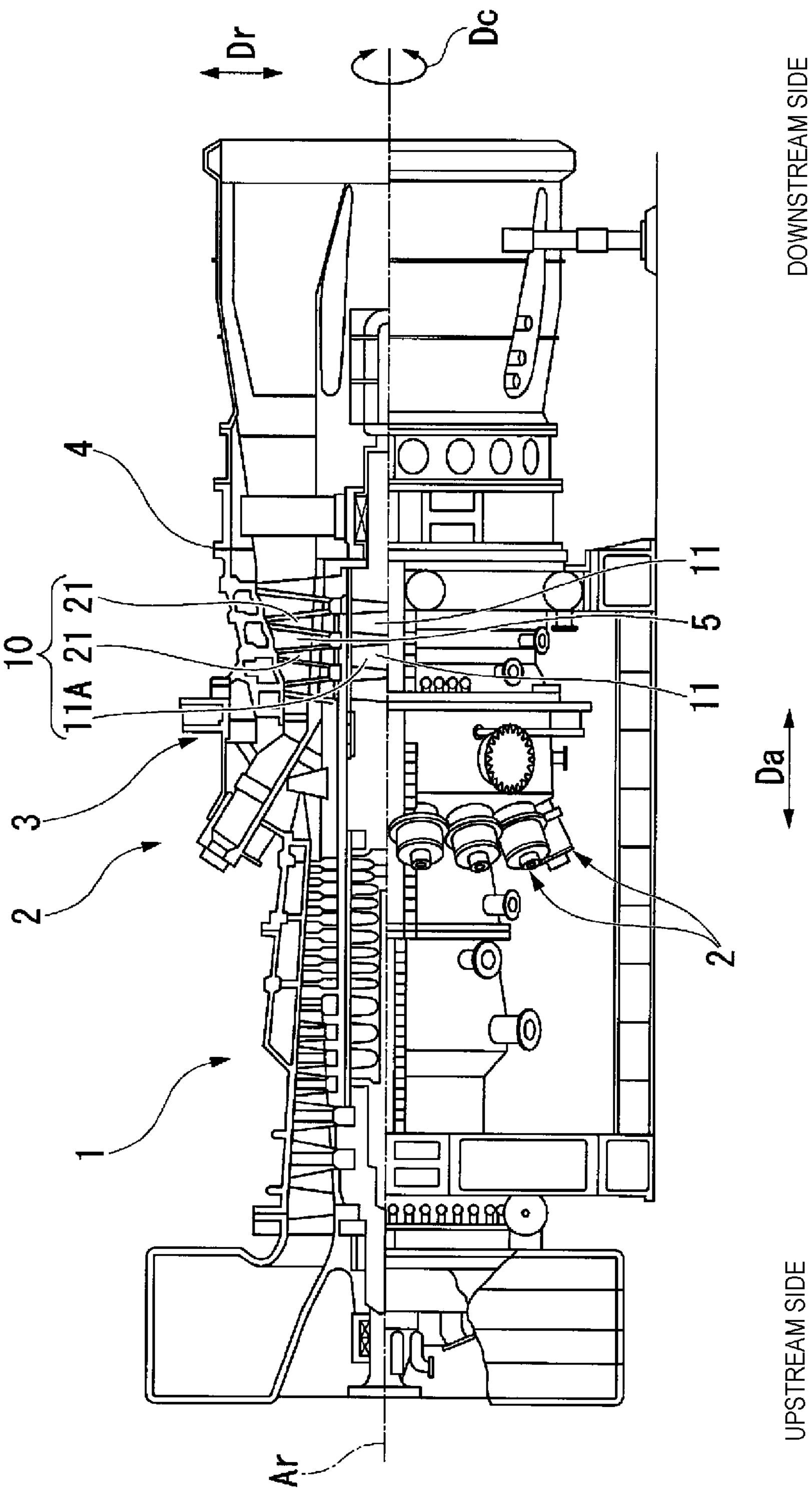
Dr
Dc
DOWNSTREAM SIDE
4
10
11A
21
21
11
5
11
3
2
Da
2
1
UPSTREAM SIDE
Ar

FIG. 1

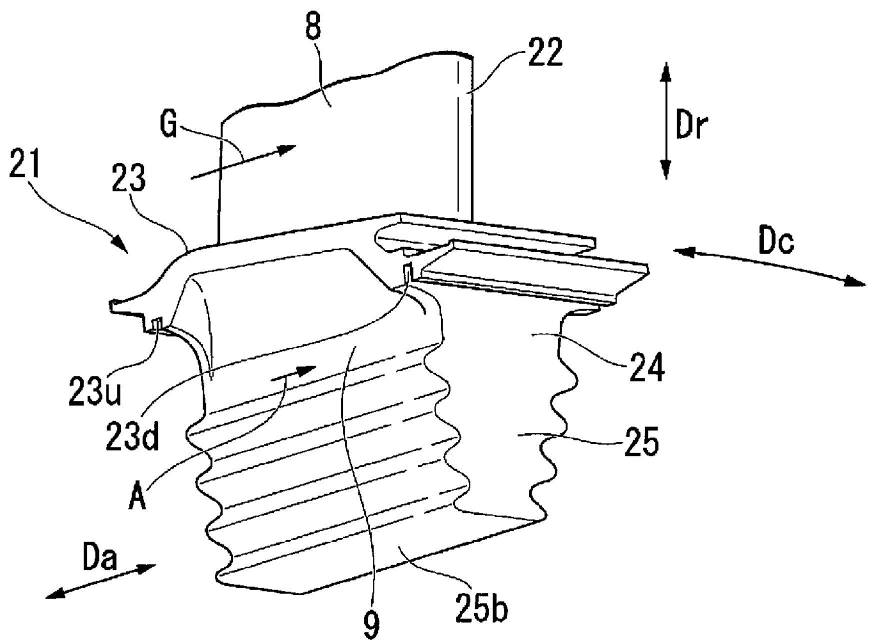

FIG. 2

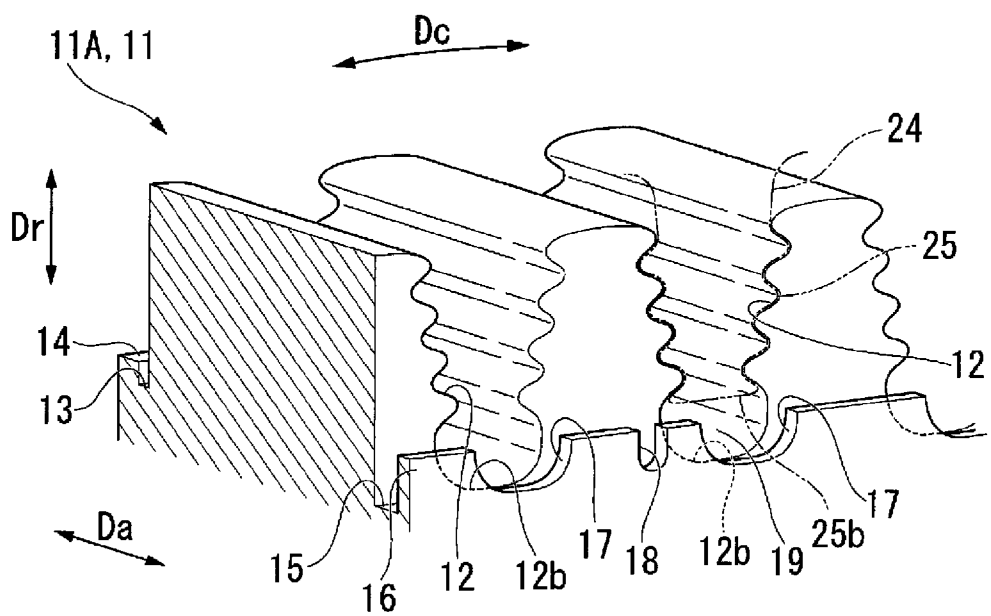

FIG. 3

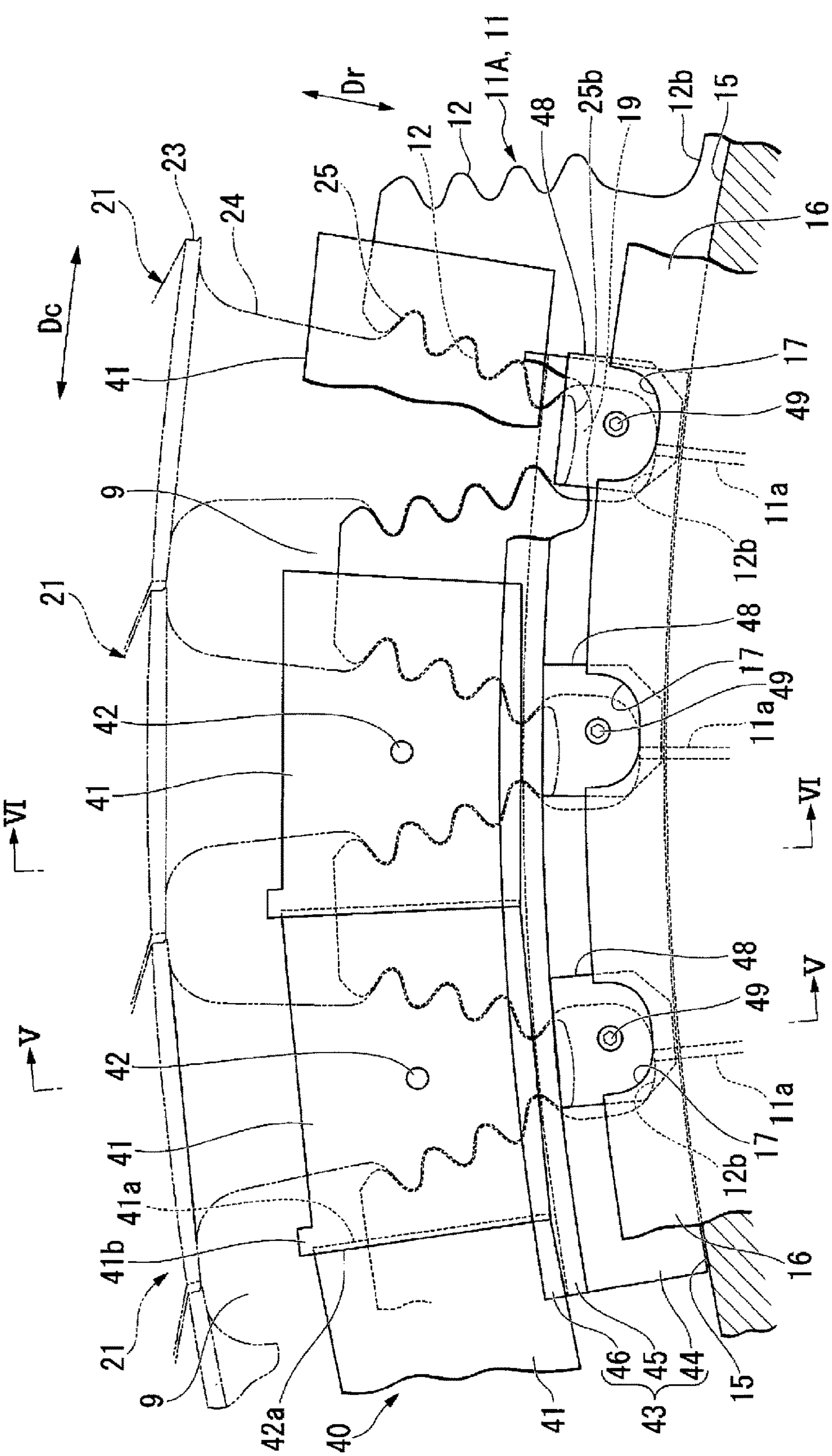
Dr
Dc
11A, 11
12
12
25
25b
48
19
12b
15
16
23
24
21
41
17
49
11a
9
12b
42
48
17
49
11a
VI
VI
V
V
48
49
17
12b
11a
16
41a
41b
21
9
42a
40
41
46
45
44
43
15

FIG. 4

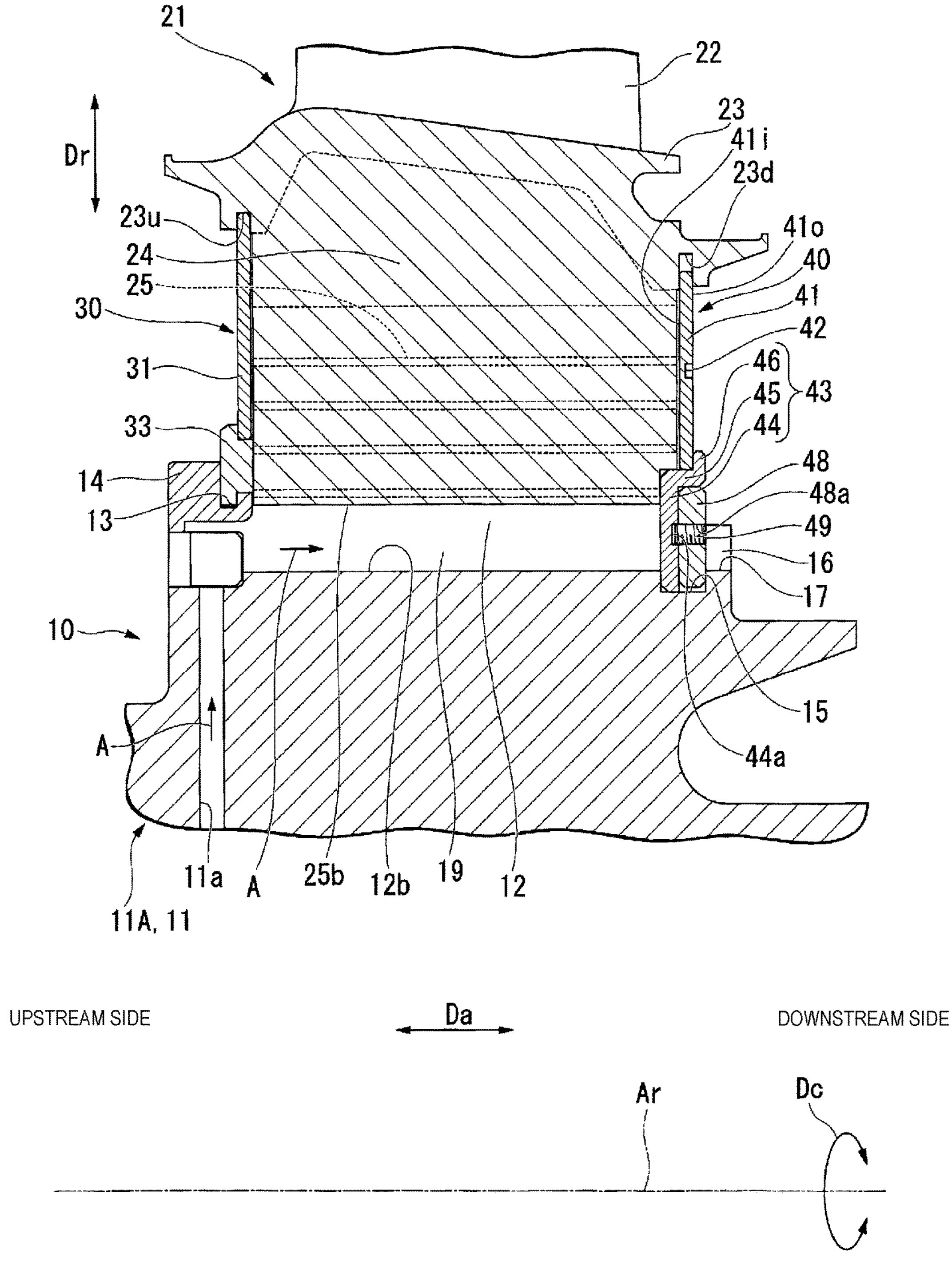
21
22
23
41i
23d
Dr
23u
41o
24
40
25
41
30
42
31
46
45
43
33
44
14
48
48a
13
49
16
17
10
15
A
44a
11a
A
25b
12b
19
12
11A, 11
UPSTREAM SIDE
Da
DOWNSTREAM SIDE
Ar
Dc

FIG. 5

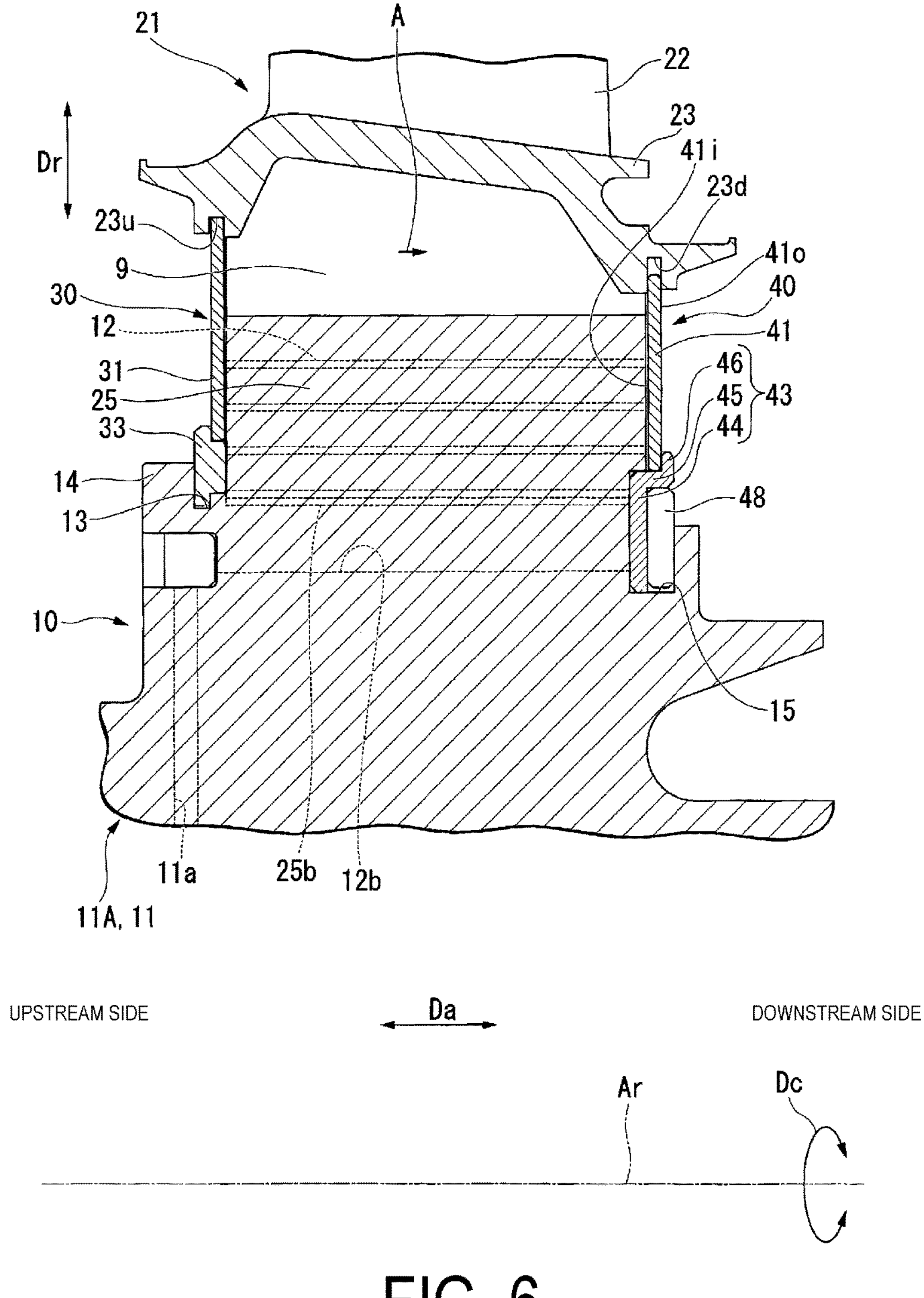
21
A
22
23
Dr
41i
23d
23u
41o
9
40
30
12
41
31
46
25
45
43
33
44
14
48
13
10
15
11a
25b
12b
11A, 11
UPSTREAM SIDE
Da
DOWNSTREAM SIDE
Ar
Dc

FIG. 6

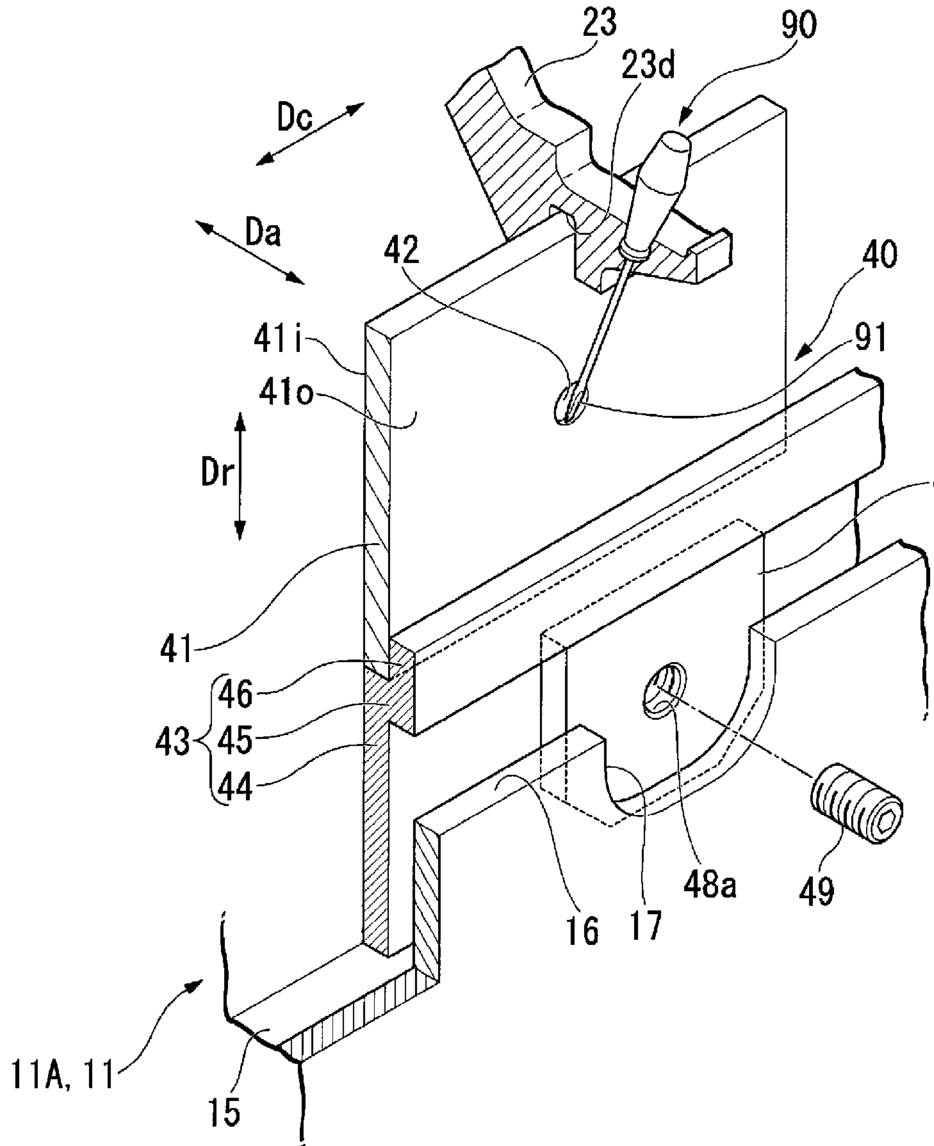
23
23d
90
Dc
Da
42
40
41i
41o
91
Dr
48
41
46
43
45
44
48a
49
16
17
11A, 11
15

FIG. 7

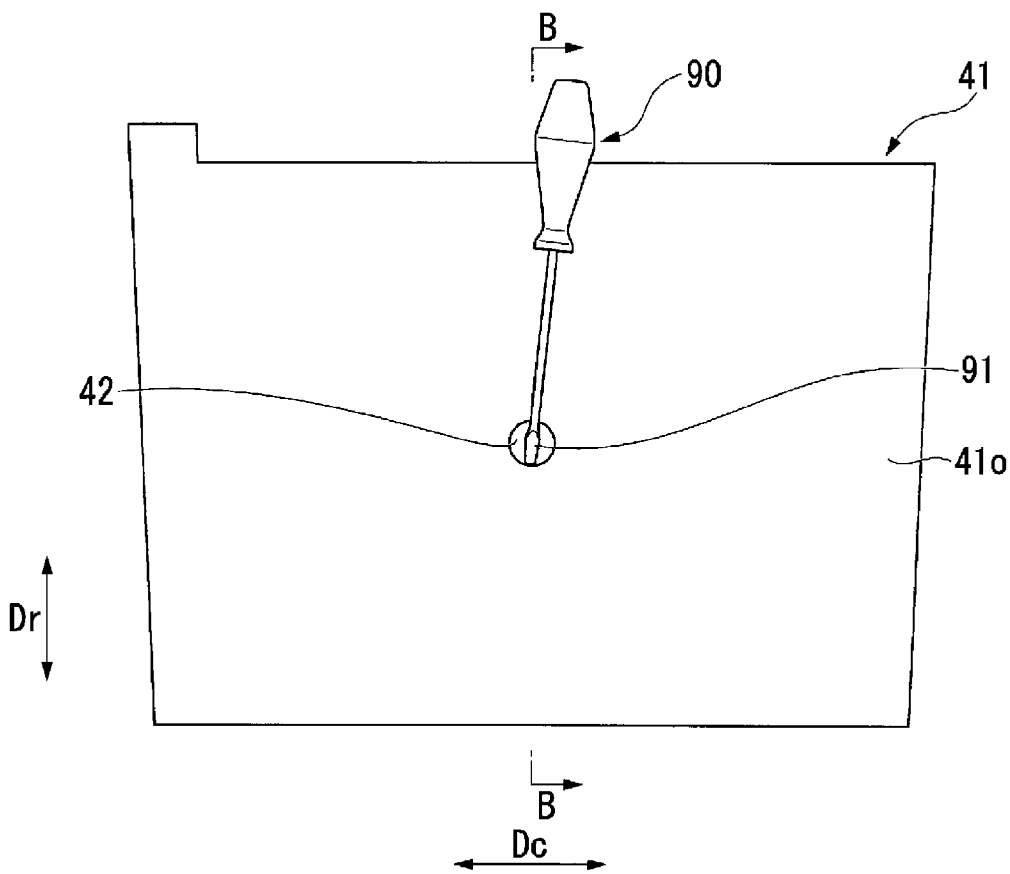

FIG. 8A

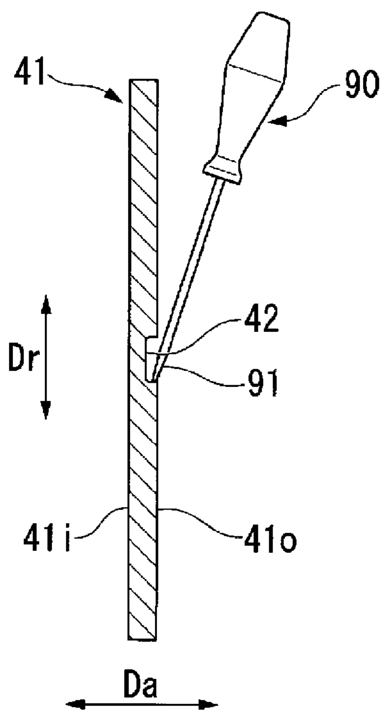

FIG. 8B

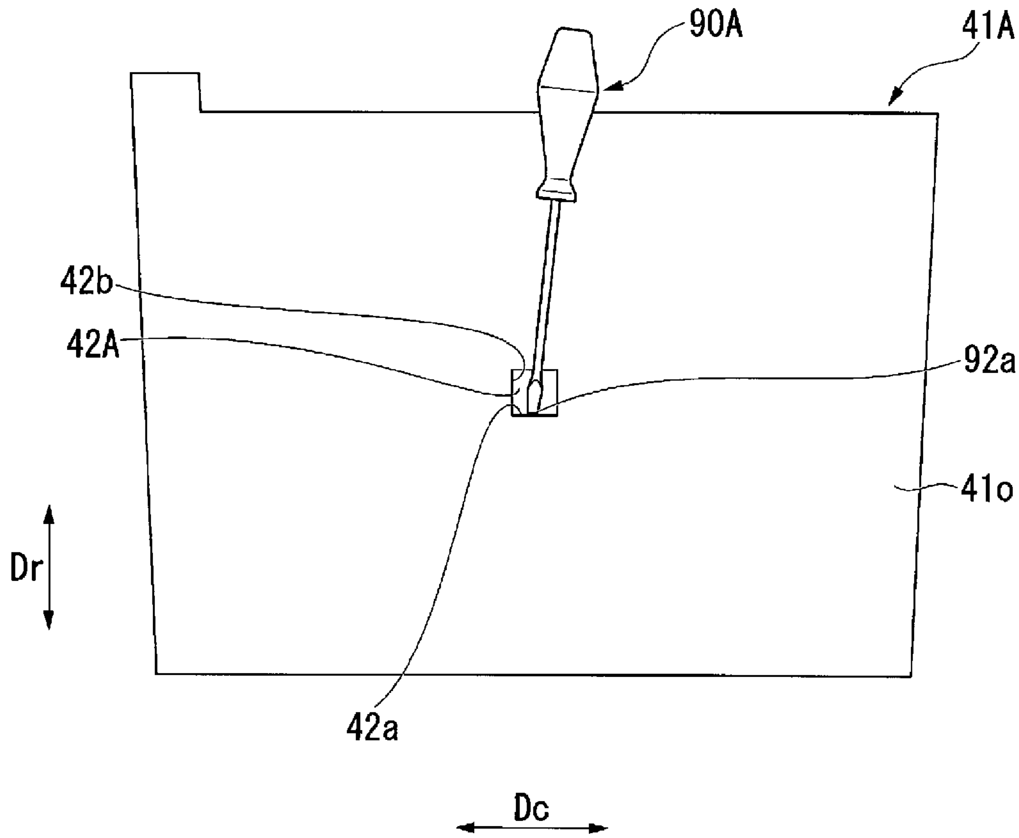

FIG. 9

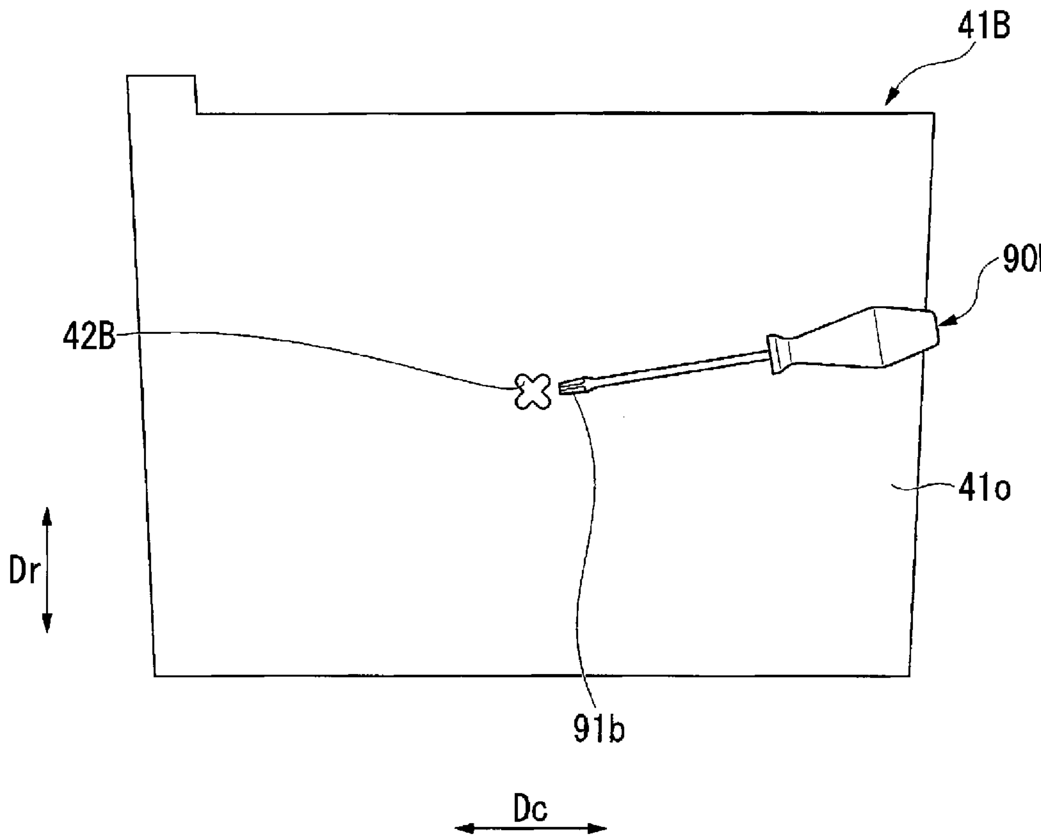

FIG. 10

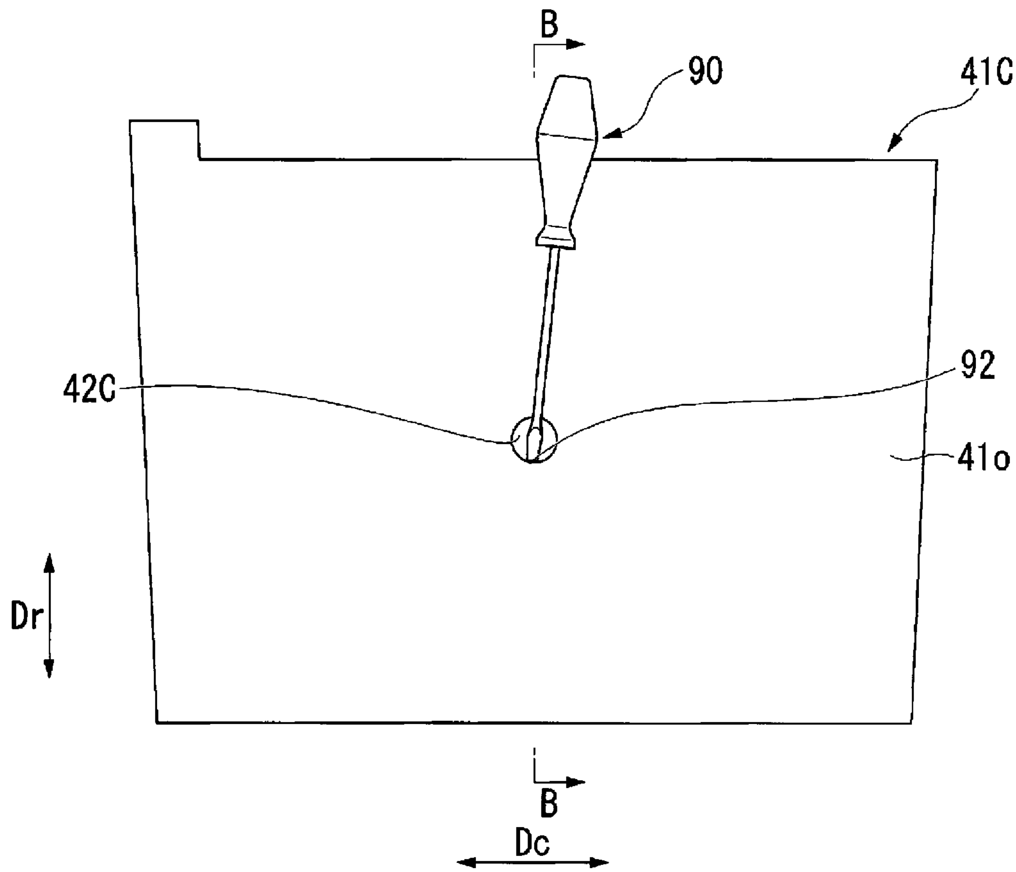

FIG. 11A

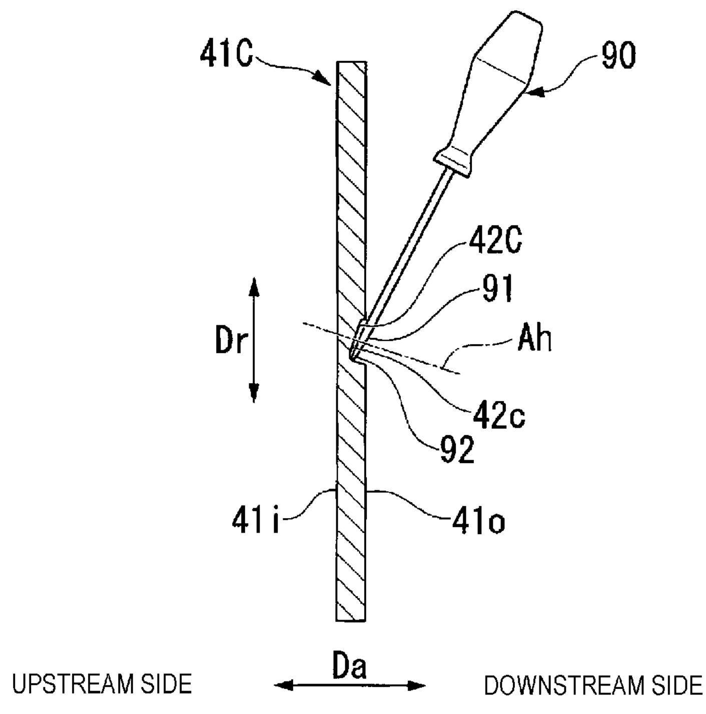
41C
90
42C
91
Dr
Ah
42c
92
41i
41o
UPSTREAM SIDE
Da
DOWNSTREAM SIDE

FIG. 11B

TURBINE ROTOR, TURBINE, AND METHOD FOR REMOVING SEAL PLATE

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority based on Japanese Patent Application No. 2013-060143 filed on Mar. 22, 2013, the contents of which are incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to a turbine rotor that includes a seal plate that is disposed on at least one side in an axial direction of a blade root of a blade and that seals off a flow of gas in the axial direction, a turbine including this turbine rotor, and a method for removing a seal plate.

BACKGROUND ART

The turbine rotor of a gas turbine includes a rotor shaft part that extends in an axial direction with an axial line serving as the center, and a plurality of blades aligned in a peripheral direction with respect to the axial line and secured to the rotor shaft part.

The turbine rotor further includes a seal assembly for sealing off a flow of gas in the axial direction in a space between blades adjacent in the peripheral direction, in a region on the inner side in the radial direction of a platform of the blades.

Such a seal assembly is disclosed, for example, in U.S. Pat. No. 4,021,138. This seal assembly includes a seal plate that seals off a flow of gas in the axial direction in the aforementioned space, and a bolt and washer for suppressing movement of the seal plate in the peripheral direction.

An outside groove recessed outward in the radial direction and extending in the peripheral direction is formed on an end portion in the axial direction of the platform of the blade. Further, an inside groove recessed inward in the radial direction and extending in the peripheral direction is formed on the rotor shaft part in a position facing the outside groove of the blade in the radial direction.

The end portion on the outer side in the radial direction of the seal plate is fitted into the outside groove of the platform, and the end portion on the inner side in the radial direction of the seal plate is fitted into the inside groove of the rotor shaft part.

Technical Problem

According to the technique described in U.S. Pat. No. 4,021,138, when the turbine is operated for a long period of time, the seal plate becomes affixed with dust and the like to the groove, making it extremely difficult to remove this seal plate from the groove. Further, when an attempt is made to forcibly remove this seal plate from the groove, the seal plate may be damaged.

SUMMARY OF INVENTION

Therefore, an object of the present invention is to provide a turbine rotor including a seal plate that can be easily removed from a groove, a turbine including this turbine rotor, and a method for removing a seal plate.

Solution to Problem

According to an aspect of the present invention for resolving the above-described problems, a turbine rotor

includes: a rotor shaft part extending in an axial direction; a plurality of blades secured to an outer periphery of the rotor shaft part; a seal plate disposed facing a blade root of each of the blades on at least one side in the axial direction of the blade root, the seal plate being configured to be fitted into a groove and to seal off a flow of gas in the axial direction, the groove being formed in a platform of each of the blades so as to be recessed toward the outer side in the radial direction and to extend in the peripheral direction; and a locking plate disposed on the inner side in the radial direction of the seal plate, the locking plate being engaged with an end portion on the inner side in the radial direction of the seal plate with both partially overlapping each other in the radial direction. In such a turbine rotor, a blind hole is formed in the outside surface of the seal plate opposite the inside surface of the seal plate that faces the blade root and is configured to enable a removing tool to be inserted therein, the inside surface of the seal plate is flat across its entirety in the radial direction, and the outside surface of the seal plate is flat across its entirety in the radial direction, excluding the hole.

It should be noted that, in the above, the axial direction refers to the direction in which an axial line serving as the center of the rotor shaft part extends, the radial direction refers to the radial direction relative to this axial line, and the peripheral direction refers to the peripheral direction relative to this axial line.

According to the turbine rotor, the seal plate can be easily removed from the groove by inserting the removing tool into the hole formed in this seal plate and applying force toward the inner side in the radial direction, and, if necessary, applying force in the peripheral direction, to this removing tool.

As described above, when force is applied to the removing tool, it is preferable that slight force in a direction toward the blade root be also applied to the removing tool to ensure that the insertion portion of this removing tool does not disengage from the hole. Even if the force in a direction toward the blade root is thus applied to the removing tool, the insertion portion of this removing tool will not pierce through the seal plate since the hole is blind. Therefore, according to the turbine rotor, the removing tool can be easily operated.

According to the turbine rotor, the inside surface of the seal plate is flat across its entirety in the radial direction and thus, when this seal plate is removed from the groove, it does not catch on the blade root or the like that faces the inside surface of the seal plate during the movement of the seal plate toward the inner side in the radial direction. Therefore, according to the turbine rotor, the seal plate can be easily removed from the groove from this perspective as well. Additionally, according to the turbine rotor, the inside surface of the seal plate is flat across its entirety in the radial direction, preventing any extra gap from forming between the seal plate and the blade root of the blade, and making the sealing effect more readily exhibitable.

According to this turbine rotor, the outside surface of the seal plate is flat across its entirety in the radial direction, excluding the hole, making it possible to suppress manufacturing costs. In particular, if the inside surface is also flat across its entirety in the radial direction, the seal plate is flat in shape, excluding the hole portion, making it possible to further suppress manufacturing costs.

Further, in any one of the seal plates of the turbine rotor, the hole may be formed in the center portion in the peripheral direction and the radial direction.

According to the seal plate, the hole is formed in the center portion in the peripheral direction and the radial direction, thereby allowing the removing tool to easily approach the hole from every direction orthogonal to the axial direction.

Further, in any one of the seal plates of the turbine rotor, the opening shape of the hole may correspond to the cross-sectional shape of the insertion portion of the removing tool to be inserted into the hole.

According to the seal plate, the insertion portion of the removing tool and the tool hole readily fit together, improving the operability of the removing tool.

Further, in any one of the seal plates of the turbine rotor, the opening shape of the hole may be a circle.

According to the seal plate, this hole can be formed very easily using an end mill or drill with an outer diameter corresponding to the size of the opening of the hole. Thus, by making the opening shape of the hole circular, it is possible to suppress the manufacturing costs of the seal plate. Additionally, according to the seal plate, since the opening shape of the hole is a circle, force is easily applied from the removing tool to the seal plate regardless of the angle at which the removing tool is inserted, making it easy to perform the operation even if the space is narrow.

Further, in any one of the seal plates of the turbine rotor, the opening shape of the hole may be a polygon.

When the opening shape of the hole is a polygon, it becomes easy to apply force from the removing tool to the seal plate in a direction orthogonal to a side that forms the edge of the opening. In particular, if any one side that forms the edge of the polygonal opening is orthogonal to the radial direction, it becomes easy to apply force from the removing tool to the seal plate in the radial direction. Furthermore, when the opening shape of the hole is a polygon, it becomes easy to apply force from the removing tool to the seal plate using a corner of the polygon.

Further, in any one of the seal plates of the turbine rotor, the depth of the hole may gradually increase from the outer side in the radial direction toward the inner side in the radial direction on the opposite side to the outer side in the radial direction.

A bottom surface of the hole in the seal plate gradually inclines in a direction toward the blade root, from the outer side in the radial direction toward the inner side in the radial direction. As a result, according to the seal plate, it allows the removing tool to easily approach the hole from the outer side in the radial direction to the inner side in the radial direction that is the side nearer to the blade root. Further, according to the seal plate, when the removing tool is inserted into the hole and force is applied to the removing tool toward the inner side in the radial direction, the insertion end of the removing tool is positioned in the deepest position in the hole, making the insertion portion of the removing tool less likely to disengage from the hole.

Further, according to an aspect of the present invention for resolving the above-described problems, a turbine includes the turbine rotor and a casing that rotatably covers the turbine rotor.

Further, according to an aspect of the present invention for resolving the above-described problems, a method for removing a seal plate of a turbine rotor in which the turbine rotor includes: a rotor shaft part extending in an axial direction; a plurality of blades secured to the outer periphery of the rotor shaft part; a seal plate disposed facing a blade root of each of the blades on at least one side in the axial direction of the blade root, the seal plate being configured to be fitted into a groove and to seal off a flow of gas in the axial direction, the groove being formed in a platform of each of the blades so as to be recessed toward the outer side in the radial direction and to extend in the peripheral direction; and a locking plate disposed on the inner side in the radial direction of the seal plate, the locking plate being engaged with an end portion on the inner side in the radial direction of the seal plate with both partially overlapping each other in the radial direction, includes the steps of: forming a blind hole in advance that allows a removing tool to be inserted therein in a surface of the seal plate opposite another surface of the seal plate that faces the blade root; removing the locking plate; and removing the seal plate by inserting the removing tool into the hole and operating the removing tool to move the seal plate to the inner side in the radial direction and in the peripheral direction of the turbine rotor or at least to the inner side in the radial direction.

According to an aspect of the present invention for resolving the above-described problems, a seal plate of a turbine rotor is disposed facing a blade root of a blade secured to a rotor shaft part on at least one side in the axial direction of the blade root and is configured to be fitted into a groove and to seal off a flow of gas in the axial direction. The groove is formed in a platform of the blade so as to be recessed toward the outer side in the radial direction and to extend in the peripheral direction. In such a seal plate, a blind hole is formed in an outside surface opposite an inside surface that faces the blade root and is configured to allow a removing tool to be inserted therein.

Advantageous Effects of Invention

According to an aspect of the present invention, the seal plate can be easily removed from the groove by inserting the removing tool into the hole formed in this seal plate and applying force toward the inner side in the radial direction, and, if necessary, applying force in the peripheral direction, to this removing tool.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a cutaway side view illustrating the main portion of a gas turbine of an embodiment according to the present invention.

FIG. **2** is a perspective view illustrating the main portion of a blade of the embodiment according to the present invention.

FIG. **3** is a perspective view illustrating the main portion of a rotor disk of the embodiment according to the present invention.

FIG. **4** is a view illustrating a portion on the outer side in the radial direction of the rotor disk of the embodiment according to the present invention, as viewed from the downstream side.

FIG. **5** is a cross-sectional view taken along a line V-V of FIG. **4**.

FIG. **6** is a cross-sectional view taken along a line VI-VI of FIG. **4**.

FIG. **7** is a perspective view illustrating a downstream-side seal assembly of the embodiment according to the present invention.

FIG. **8**A is a plan view illustrating a downstream-side seal plate of the embodiment according to the present invention.

FIG. **8**B is a cross-sectional view taken along a line B-B of FIG. **8**A.

FIG. **9** is a plan view illustrating the downstream-side seal plate of a first modification according to the present invention.

FIG. **10** is a plan view illustrating the downstream-side seal plate of a second modification according to the present invention.

FIG. **11**A is a plan view illustrating the downstream-side seal plate of a third modification according to the present invention.

FIG. **11**B is a cross-sectional view taken along a line B-B of FIG. **11**A.

DESCRIPTION OF EMBODIMENTS

The following describes in detail an embodiment of a turbine according to the present invention, with reference to the drawings.

As illustrated in FIG. **1**, a gas turbine includes a compressor **1** that compresses outside air to generate compressed air, a combustor **2** that mixes a fuel from a fuel supply source with the compressed air and combusts the mixture to generate a combustion gas, and a turbine **3** that is driven by the combustion gas.

The turbine **3** includes a casing **4**, and a turbine rotor **10** that rotates inside this casing **4**. This turbine rotor **10** is, for example, connected to a generator (not illustrated) that generates power by the rotation of this turbine rotor **10**. It should be noted that, hereinafter, the direction in which an axial line Ar extends, which serves as the center of rotation of the turbine rotor **10**, will be referred to as axial direction Da. Further, in a radial direction Dr with respect to the axial line Ar, the side nearer to the axial line Ar will be referred to as the inner side in the radial direction, and the side farther away from the axial line Ar will be referred to as the outer side in the radial direction. Furthermore, the upstream side and the downstream side of the flow of combustion gas in the axial direction Da will be simply referred to as the upstream side and the downstream side.

The turbine rotor **10** includes a rotor shaft part **10**A that extends in the axial direction Da with the axial line Ar serving as the center, and a plurality of blades **21** aligned in a peripheral direction Dc relative to the axial line Ar and secured to the outer periphery of the rotor shaft part **10**A. The rotor shaft part **10**A is formed with a plurality of rotor disks **11** aligned in the axial direction Da and interconnected. The aforementioned plurality of blades **21** are secured to the outer peripheries of the respective rotor disks **11**. On the inner periphery of the casing **4**, a plurality of vanes **5** are aligned in the peripheral direction Dc and secured as a vane row on the respective upstream sides of the blades **21** of the rotor disks **11**.

The blade **21**, as illustrated in FIG. **2**, includes a blade body **22** that extends in the radial direction Dr, a platform **23** that is provided on the inner side in the radial direction of this blade body **22**, a shank **24** that is provided on the inner side in the radial direction of the platform **23**, and a blade root **25** that is provided on the inner side in the radial direction of the shank **24**. A region on the outer side in the radial direction of the platform **23**, that is, the region where the blade body **22** exists, forms a combustion gas flow path **8** through which a combustion gas G from the combustor **2** passes. On the other hand, in the region on the inner side in the radial direction of the platform **23** of the blade **21**, the space between the blades **21** adjacent in the peripheral direction Dc forms a cooling air space **9** into which cooling air A flows.

Outside grooves **23***u*, **23***d* that are recessed from the inner side in the radial direction toward the outer side in the radial direction and extend in the peripheral direction Dc are formed on an upstream end portion and downstream end portion of the platform **23**, respectively. Further, the cross-sectional shape of the blade root **25** that is orthogonal to a blade chord direction in which the blade chord extends so as to connect the upstream end and the downstream end of the blade body **22** forms a Christmas-tree shape wherein a widened part and a narrowed part are alternately repeated toward the inner side in the radial direction.

A blade root groove **12** into which the blade root **25** of the blade **21** is fitted is formed on the rotor disk **11**, as illustrated in FIG. **3**. This blade root groove **12** passes through the rotor disk **11** in the axial direction Da, forming a cross-sectional shape that corresponds to the cross-sectional Christmas-tree shape of the blade root **25**. Accordingly, this blade root groove **12** forms a shape in which a widened space that has the widened part of the blade root **25** fitted therein and a narrowed space that has the narrowed part of the blade root **25** fitted therein are alternately repeated toward the inner side in the radial direction. It should be noted that, in this embodiment, of the plurality of widened spaces of the blade root groove **12**, the widened space positioned on the innermost side in the radial direction is formed significantly larger than the size of the plurality of widened parts of the blade root **25**. As a result, according to this embodiment, when the blade root **25** of the blade **21** is fitted into the blade root groove **12** of the rotor disk **11**, there is a gap in the radial direction between a surface on the innermost side in the radial direction of the blade root **25**, that is, a bottom surface **25***b* of the blade root **25**, and a surface on the inner side in the radial direction of the widened space that is positioned on the innermost side in the radial direction of the blade root groove **12**, that is, a groove bottom surface **12***b* of the blade root groove **12**. According to this embodiment, the gap between the groove bottom surface **12***b* of the blade root groove **12** and the bottom surface **25***b* of the blade root **25** forms an in-groove cooling air path **19**. This in-groove cooling air path **19** passes through the rotor disk **11** in the axial direction Da.

Inside grooves **13**, **15** recessed from the outer side in the radial direction to the inner side in the radial direction and extending in the peripheral direction Dc are formed on the upstream side and the downstream side of this blade root groove **12**, respectively. The inside groove **13** on the upstream side faces the outside groove **23***u* on the upstream side of the platform **23** in the radial direction Dr. Further, the inside groove **15** on the downstream side faces the outside groove **23***d* on the downstream side of the platform **23** in the radial direction Dr. Of the pair of surfaces of the inside groove **13** on the upstream side that face each other in the axial direction Da, an upstream-side surface is formed by an upstream-side barrier **14**. Further, of the pair of surfaces of the inside groove **15** on the downstream side that face each other in the axial direction Da, a surface on the downstream side is formed by a downstream barrier **16**.

A plurality of screw operation openings **17** are formed in the downstream barrier **16**. The plurality of screw operation openings **17** that penetrate in the axial direction Da are made by cutting out the downstream barrier **16** from the outer side in the radial direction toward the inner side in the radial direction. Each of the plurality of screw operation openings **17** is formed in a position facing the blade root groove **12** in the axial direction Da, in other words, in the same position as the blade root groove **12** in the peripheral direction Dc.

As illustrated in FIGS. **4** to **6**, a radial cooling air path **11***a* that extends from the inner side in the radial direction to the outer side in the radial direction and opens at the groove bottom surface **12***b* of the blade root groove **12** is formed in the rotor disk **11**. It should be noted that FIG. **4** is a view illustrating a portion on the outer side in the radial direction of the rotor disk **11**, as viewed from the downstream side, FIG. **5** is a cross-sectional view taken along a line V-V of FIG. **4**, and FIG. **6** is cross-sectional view taken along a line VI-VI of FIG. **4**. The cooling air A (FIG. **5**) that passes through the radial cooling air path **11***a* flows inside the in-groove cooling air path **19**, where a portion of the cooling air A passes through the cooling air path (not illustrated) formed in the blade root **25** of the blade **21** to cool the blade **21**, and the other portion flows into the aforementioned cooling air space **9** (FIG. **2**, FIG. **6**).

The turbine rotor **10** further includes an upstream-side seal assembly **30** that seals off the aforementioned cooling air space **9** at the position of an upstream end portion of the platform **23** of the blade **21**, and a downstream-side seal assembly **40** that seals off the cooling air space **9** at the position of a downstream end portion of the platform **23** of the blade **21**.

The upstream-side seal assembly **30** includes an upstream-side seal plate **31** disposed facing the upstream side of the blade root **25**, and an upstream-side locking plate **33** disposed on the inner side in the radial direction of this upstream-side seal plate **31**. The upstream-side seal plate **31** and the upstream-side locking plate **33** each form a plate shape, and the thickness direction thereof is the same as the axial direction Da. The end portion on the outer side in the radial direction of the upstream-side seal plate **31** is fitted into the outside groove **23***u* on the upstream side of the platform **23**. Further, the end portion on the inner side in the radial direction of the upstream-side locking plate **33** is fitted into the inside groove **13** on the upstream side of the rotor disk **11**. The end portion on the inner side in the radial direction of the upstream-side seal plate **31** and the end portion on the outer side in the radial direction of the upstream-side locking plate **33** are engaged with both overlapping each other in the radial direction.

The downstream-side seal assembly **40**, as illustrated in FIGS. **4** to **7**, includes a downstream-side seal plate **41** disposed facing the downstream side of the blade root **25**, a downstream-side locking plate **43** disposed on the inner side in the radial direction of this downstream-side seal plate **41**, and a receiving plate **48** and a push screw **49** for pressing this downstream-side locking plate **43** toward the upstream side.

The downstream-side seal plate **41** and the downstream-side locking plate **43** each form a plate shape, and the thickness direction thereof is the same as the axial direction Da. The end portion on the outer side in the radial direction of the downstream-side seal plate **41** is fitted into the outside groove **23***d* on the downstream side of the platform **23**. Further, the end portion on the inner side in the radial direction of the downstream-side locking plate **43** is fitted into the inside groove **15** on the downstream side of the rotor disk **11**. The downstream-side seal plate **41** closes the downstream end portion of the cooling air space **9** in the axial direction Da, and the downstream-side locking plate **43** closes the downstream-side end portion of the in-groove cooling air path **19** in the axial direction Da. The end portion on the inner side in the radial direction of the downstream-side seal plate **41** and the end portion on the outer side in the radial direction of the downstream-side locking plate **43** are engaged with both overlapping each other in the radial direction Dr.

A blind tool hole **42** recessed toward the blade root side, that is, the upstream side, is formed in an outside surface **41***o* of the downstream-side seal plate **41**, the outside surface **41***o* being on the side opposite an inside surface **41***i* that faces the blade root **25**. This outside surface **41***o* is flat across its entirety in the radial direction Dr, excluding this tool hole **42**. Further, the inside surface **41***i* on the side opposite the outside surface **41***o* is flat across its entirety in the radial direction Dr. The tool hole **42**, as illustrated in FIG. **8**A and FIG. **8**B, is formed in the center portion in the radial direction Dr and the peripheral direction Dc of the downstream-side seal plate **41**. This tool hole **42** forms a cylinder shape with an axis directed in the axial direction Da serving as the center, and is formed by a drill, end mill, or the like, for example. The inner diameter of the circular opening of this tool hole **42** is set to a dimension that permits an insertion portion **91** of a removing tool **90** to be inserted into the tool hole **42**. The removing tool **90** is, for example, a flathead screwdriver, a Phillips screwdriver, or the like.

The downstream-side locking plate **43**, as illustrated in FIGS. **4** to **7**, includes a plate main body part **44** that forms a flat-plate shape, extends in the peripheral direction Dc, and is inserted into the inside groove **15** on the downstream side of the rotor disk **11**, a rising part **45** that extends from the end portion on the outer side in the radial direction of the plate main body part **44** to the downstream side, and a lap part **46** that extends from the downstream end portion of the rising part **45** to the outer side in the radial direction. That is, the cross-sectional shape of this downstream-side locking plate **43** forms a crank shape. A screw abutting part **44***a* (FIG. **5**) where the distal edge of the push screw **49** abuts is formed on the outside surface facing the downstream side of the plate main body part **44** of this downstream-side locking plate **43**. The end portion on the inner side in the radial direction of the downstream-side seal plate **41** is positioned on the outer side in the radial direction of the rising part **45** of the downstream-side locking plate **43** and on the upstream side of the lap part **46**, overlapping this lap part **46** in the radial direction Dr.

The receiving plate **48** forms a plate shape, and is inserted into the inside groove **15** on the downstream side of the rotor disk **11** along with the plate main body part **44** of the downstream-side locking plate **43**, with the thickness direction of the receiving plate **48** being the same as the axial direction Da. At this time, the receiving plate **48** is positioned between the downstream barrier **16** and the plate main body part **44** of the downstream-side locking plate **43** in the axial direction Da, in the same position as the screw operation opening **17** of the downstream barrier **16** in the peripheral direction Dc. The dimensions of the receiving plate **48** in the peripheral direction Dc and the radial direction Dr are both larger than the dimensions of the screw operation opening **17** in the peripheral direction Dc and the radial direction Dr, respectively. A female screw hole **48***a* that penetrates in the axial direction Da and permits the screwing of the push screw **49** is formed in this receiving plate **48**.

When the downstream-side locking plate **43** and the receiving plate **48** are disposed in the inside groove **15** on the downstream side, the receiving plate **48** and the plate main body part **44** of the downstream-side locking plate **43** are inserted into the inside groove **15** on the downstream side, and the push screw **49** is screwed into the receiving plate **48**.

The plurality of downstream-side seal plates **41**, as illustrated in FIG. **4**, are disposed in a ring shape around the axial line Ar, and each end portion **41***a* in the peripheral direction of the downstream-side seal plates **41** forms an overlapping structure in which the end portion **41***a* in the peripheral direction overlaps the end portion **41***a* in the peripheral direction of another downstream-side seal plate **41** adjacent in the peripheral direction Dc. With this arrangement, the cooling air inside the cooling air space **9** is prevented from leaking from the area between the end portions **41***a* in the peripheral direction of the downstream-side seal plates **41** adjacent in the peripheral direction Dc into the combustion gas.

Further, a protrusion portion **41***b* that projects toward the outer side in the radial direction is provided on the end portion on the outer side in the radial direction of the downstream-side seal plate **41**. The end portion on the outer side in the radial direction of the downstream-side seal plate **41** including the protrusion portion **41***b* is fitted into the outside groove **23***d*. At this time, the protrusion portion **41***b* of the downstream-side seal plate **41** abuts against a step (not illustrated) provided in the outside groove **23***d*, thereby regulating the movement of this downstream-side seal plate **41** in the peripheral direction Dc.

Next, a procedure for disassembling the downstream-side seal assembly **40** (a procedure for removing the downstream-side seal plate **41**) having been described above will be described. This downstream-side seal assembly **40** is disassembled during inspection of the turbine **3**, for example.

First, the push screw **49** that has been screwed into the receiving plate **48** is turned and removed from the receiving plate **48**. Next, the receiving plate **48** from which the push screw **49** has been removed is moved toward the outer side in the radial direction and removed from the inside groove **15** on the downstream side. As a result, the downstream-side locking plate **43** in which the plate main body part **44** has been inserted in the inside groove **15** becomes movable in the axial direction Da as well as the peripheral direction Dc in the inside groove **15**.

Hence, this downstream-side locking plate **43** is moved to the downstream side in the axial direction Da as well as in the peripheral direction Dc, and removed from the inside groove **15** on the downstream side. When the downstream-side locking plate **43** is thus removed, the downstream-side seal plate **41** becomes movable basically to the inner side in the radial direction.

However, when the turbine **3** is operated for a long period of time, foreign matter and the like enter the slight gap between the end portion on the outer side in the radial direction of the downstream-side seal plate **41** and the outside groove **23***d* on the downstream side, causing this downstream-side seal plate to be affixed or nearly affixed to the outside groove **23***d*. Consequently, even if the downstream-side locking plate **43** is removed as described above, making the downstream-side seal plate **41** movable to the inner side in the radial direction, it is basically difficult to easily remove this downstream-side seal plate **41** from the outside groove **23***d*.

Nevertheless, according to this embodiment, this downstream-side seal plate **41** can be easily removed from the outside groove **23***d* by using the removing tool **90**, as illustrated in FIG. **7**, FIG. **8**A, and FIG. **8**B. Specifically, this downstream-side seal plate **41** can be easily removed from the outside groove **23***d* by inserting the insertion portion **91** of the removing tool **90**, such as a flathead screwdriver, a Phillips screwdriver, or the like, into the tool hole **42** formed in the downstream-side seal plate **41** and applying force toward the inner side in the radial direction, and, as necessary, force in the peripheral direction Dc, to this removing tool **90**.

When force is applied to the removing tool **90**, it is preferable that slight force in a direction toward the blade root **25**, that is, force in a direction toward the upstream side be also applied to the removing tool **90** to ensure that the insertion portion **91** of this removing tool **90** does not disengage from the tool hole **42**. Even if force toward the upstream side is thus applied to the removing tool **90**, the insertion portion **91** of this removing tool **90** does not pierce through the downstream-side seal plate **41** since the tool hole **42** of this embodiment is blind. As a result, according to this embodiment, it is possible to easily operate the removing tool **90**.

Further, according to this embodiment, the inside surface **41***i* of the downstream-side seal plate **41** is flat across its entirety in the radial direction Dr and thus, when this downstream-side seal plate **41** is removed from the outside groove **23***d*, it does not catch on the blade root **25** or the like on the inside surface **41***i* side of the downstream-side seal plate **41**, in other words, on the upstream side during the movement of the downstream-side seal plate **41** to the inner side in the radial direction. Thus, according to this embodiment, the downstream-side seal plate **41** can be easily removed from the outside groove **23***d* from this perspective as well. Furthermore, according to this embodiment, an extra gap is not formed between the downstream-side seal plate **41** and the blade root **25** of the blade **21**, making the sealing effect more readily exhibitable.

Further, according to this embodiment, the outside surface **41***o* of the downstream-side seal plate **41** is also flat across its entirety in the radial direction Dr, excluding this tool hole **42**. Thus, the downstream-side seal plate **41** of this embodiment has a flat plate shape, excluding the portion of the tool hole **42**, making it possible to suppress manufacturing costs. Furthermore, since the hole shape of the tool hole **42** of this embodiment is cylindrical, this tool hole **42** can be very easily formed using an end mill or drill having an outer diameter corresponding to the size of the opening of this tool hole **42**. Thus, according to this embodiment, manufacturing costs can be suppressed from this perspective as well.

It should be noted that, in this embodiment, the upstream-side seal plate **31** is removed after the blade **21** is moved to the downstream side with respect to the rotor disk **11** and removed from the rotor disk **11**. For this reason, a tool hole similar to that of the downstream-side seal plate **41** does not need to be formed in the upstream-side seal plate **31**.

First Modification of Seal Plate

Next, the first modification of the downstream-side seal plate will be described with reference to FIG. **9**. It should be noted that, in the first modification and the following second and third modifications as well, only the shape of the tool hole in the downstream-side seal plate differs; all other arrangements are the same as in the above embodiment. Thus, in the first to third modifications, the shape of the tool hole is mainly described.

The shape of a tool hole **42**A in a downstream-side seal plate **41**A of this modification is a regular quadrangular prism. Thus, the opening shape of the tool hole **42**A is a square. This tool hole **42**A is, for example, formed using an end mill or drill having an outer diameter that is far smaller than the size of the opening of the tool hole **42**A. Of the inner peripheral surfaces of this tool hole **42**A, a pair of surfaces **42***a* that face each other, in other words, a pair of sides that form a square-shaped opening edge and face each other, are orthogonal to the radial direction Dr and stretch in the peripheral direction Dc. Accordingly, of the inner peripheral surfaces of the tool hole **42**A, the other pair of surfaces **42***b* that face each other are orthogonal to the peripheral direction Dc and stretch in the radial direction Dr.

As described above, the inner peripheral surfaces of the tool hole **42**A of this modification are formed by the surfaces **42***a* that are orthogonal to the radial direction Dr and stretch in the peripheral direction Dc, and the surfaces **42***b* that are orthogonal to the peripheral direction Dc and stretch in the radial direction Dr. As a result, according to this modification, when the downstream-side seal plate **41**A in which this tool hole **42**A is formed is moved to the inner side in the radial direction and in the peripheral direction Dc using a removing tool **90**A, which is a flathead screwdriver, a contact area between the inner peripheral surfaces **42***a*, **42***b* of the tool hole **42**A and an insertion end **92***a* of this removing tool **90**A increases. Thus, according to this modification, when the downstream-side seal plate **41**A is moved to the inner side in the radial direction and in the peripheral direction Dc, the force toward the inner side in the radial direction and in the peripheral direction Dc is readily transmitted from the removing tool **90**A, which is a flathead screwdriver, to the tool hole **42**A. Furthermore, force is readily applied from the removing tool to the seal plate by using a corner of the tool hole **42**A.

It should be noted that while the shape of the tool hole **42**A is a regular quadrangular prism in this modification, the shape may be a polygonal prism, such as a rectangular parallelepiped. That is, the opening shape of the tool hole may be a rectangle, trapezoid, parallelogram, pentagon, hexagon, or the like, rather than a square. In addition, while the above has described an example in which the removing tool **90**A is a flathead screwdriver, the removing tool does not need to be a flathead screwdriver in this modification as long as the removing tool can catch onto the tool hole **42**A.

Second Modification of Seal Plate

Next, the second modification of the downstream-side seal plate will be described with reference to FIG. **10**.

The opening shape of a tool hole **42**B in a downstream-side seal plate **41**B of this modification is a cross. Thus, if a Phillips screwdriver is adopted as a removing tool **90**B, the opening shape of this tool hole **42**B corresponds to the cross-sectional shape of an insertion portion **91***b* of this removing tool **90**B.

Thus, according to this modification, if the removing tool **90**B that is a Phillips screwdriver is used, the insertion portion **91***b* of this removing tool **90**B and the tool hole **42**B readily fit together, thereby improving the operability of the removing tool **90**B. It should be noted that, in the first modification of the seal plate, if the opening shape of the tool hole is a rectangle and a removing tool that is a flathead screwdriver is used, this opening shape corresponds to the cross-sectional shape of the insertion portion of this removing tool.

Third Modification of Seal Plate

Next, the third modification of the downstream-side seal plate will be described with reference to FIG. **11**A and FIG. **11**B.

An axis Ah of a tool hole **42**C in a downstream-side seal plate **41**C of this modification is gradually inclined toward the outer side in the radial direction, from the outside surface **41***o* toward the inside surface **41***i* of this downstream-side seal plate **41**C. In other words, the depth of the tool hole **42**C gradually increases from the outer side in the radial direction to the inner side in the radial direction. As a result, according to this modification, a bottom surface **42***c* of the tool hole **42**C is inclined so as to gradually become closer to the inside surface **41***i* of the downstream-side seal plate **41**C, from the outer side in the radial direction toward the inner side in the radial direction.

Thus, according to this modification, the removing tool **90** is allowed to easily approach the tool hole **42**C from the outer side in the radial direction to the inner side in the radial direction that is on the upstream side, in other words, to the side nearer to the blade. Further, when the insertion portion **91** of the removing tool **90** is inserted into the tool hole **42**C and force toward the inner side in the radial direction is applied to the removing tool **90**, an insertion end **92** of the removing tool **90** is positioned in the deepest position in the tool hole **42**C, making the insertion portion **91** of the removing tool **90** less likely to disengage from the tool hole **42**C.

It should be noted that while the opening shape of this tool hole **42**C is a circle in FIG. **11**A and FIG. **11**B, this modification is not limited to this shape, and the opening shapes of the tool hole may be a square as in the first modification, a cross as in the second modification, or the like.

Other Modifications

While the tool hole is formed in the downstream-side seal plate in the above embodiment and modifications, a similar tool hole may be formed in the upstream-side seal plate.

Further, the seal assembly of the above embodiment includes the seal plate **41**, the locking plate **43**, the receiving plate **48**, and the push screw **49**. Nevertheless, a tool hole may be formed in the same manner as in the above embodiment and modifications in a seal plate of a seal assembly of another configuration that does not include a locking plate, a receiving plate, or the like, as long as it includes a seal plate.

INDUSTRIAL APPLICABILITY

According to an aspect of the present invention, it is possible to easily remove a seal plate of a turbine rotor from a groove.

REFERENCE SIGNS LIST

1 Compressor
2 Combustor
3 Turbine
4 Casing
5 Vane
9 Cooling air space
10 Turbine rotor
11 Rotor disk
11A Rotor shaft part
12 Blade root groove
13, **15** Inside groove
14 Upstream barrier
16 Downstream barrier
17 Screw operation opening
21 Blade
22 Blade body
23 Platform
23*u*, **23***d* Outside groove (or simply groove)
25 Blade root
30 Upstream-side seal assembly
31 Upstream-side seal plate
33 Upstream-side locking plate
40 Downstream-side seal assembly
41, **41**A, **41**B, **41**C Downstream-side seal plate (or simply seal plate)
41*o* Outside surface
41*i* Inside surface
42, **42**A, **42**B, **42**C Tool hole
43 Downstream-side locking plate
48 Receiving plate
49 Push screw

The invention claimed is:

1. A method for removing a seal plate of a turbine rotor, the turbine rotor including:

a rotor shaft part extending in an axial direction;

a plurality of blades secured to an outer periphery of the rotor shaft part;

for each of the blades:

a seal plate facing a blade root of one of the blades on at least one side in the axial direction of the blade root, the seal plate being configured to be fitted into a groove and to seal off a flow of gas in the axial direction, the groove being defined in a platform of the one of the blades so as to be recessed toward an outer side in a radial direction and to extend in a peripheral direction;

a locking plate on an inner side in the radial direction of the seal plate, the locking plate being engaged with an end portion on the inner side in the radial direction of the seal plate with both the locking plate and the end portion on the inner side in the radial direction of the seal plate partially overlapping each other in the radial direction; and

a protrusion portion that projects toward the outer side in the radial direction on an end portion on the outer side in the radial direction of the seal plate, the method comprising:

forming a blind hole in advance that allows a removing tool to be inserted therein in a first surface of the seal plate opposite a second surface of the seal plate that faces the blade root;

removing the locking plate; and

removing the seal plate by inserting the removing tool into the blind hole and operating the removing tool to move the seal plate to the inner side in the radial direction and in the peripheral direction of the turbine rotor or at least to the inner side in the radial direction,

wherein the removing the seal plate is performed by applying a force toward the inner side in the radial direction to the removing tool,

wherein an inside groove which extends in the peripheral direction is defined in the rotor shaft part so that an end portion of the inner side in the radial direction of the locking plate is inserted into the inside groove, and

wherein the removing the locking plate is performed by moving the locking plate in the peripheral direction while moving the locking plate in the axial direction.

2. The method according to claim 1, wherein:

the turbine rotor further includes a receiving plate including a female screw hole that penetrates in the axial direction and is configured to permit screwing of a push screw, the receiving plate being configured to press the locking plate toward the seal plate in the axial direction, and

the method further comprises:

removing the push screw from the receiving plate by turning the push screw screwed into the receiving plate.

3. The method according to claim 2, wherein:

the inside groove which extends in the peripheral direction is defined in the rotor shaft part so that the end portion of the inner side in the radial direction of the locking plate and an end portion of the inner side in the radial direction of the receiving plate are inserted into the inside groove, and

a screw operation opening which penetrates in the axial direction is made by cutting out a barrier, which defines a surface of the inside groove, from the outer side in the radial direction toward the inner side in the radial direction.

4. The method according to claim 3, wherein

the screw operation opening is defined in the same position as a blade root groove of the blade root in the peripheral direction.

5. The method for removing a seal plate of a turbine rotor according to claim 1, wherein the seal plate is affixed to the groove.

6. The method according to claim 1, wherein the removing the seal plate is performed by inserting the removing tool into the blind hole of the seal plate while applying a force in a direction toward the blade root to the removing tool such that the removing tool does not pierce through the seal plate.

7. The method according to claim 1, wherein:

the turbine rotor further comprises a receiving plate configured to press the locking plate toward the seal plate in the axial direction,

the inside groove is defined in the rotor shaft part so that the end portion of the inner side in the radial direction of the locking plate and an end portion of the inner side in the radial direction of the receiving plate are inserted into the inside groove, and

the method further comprises removing the receiving plate from the inside groove by moving the receiving plate toward the outer side in the radial direction before the removing the locking plate.

8. The method according to claim 7, wherein:

a female screw hole that penetrates in the axial direction and is configured to permit screwing of a push screw is defined in the receiving plate, and

the method further comprises:

removing the push screw from the receiving plate by turning the push screw screwed into the receiving plate is performed before the removing the receiving plate from the inside groove.

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